REPORT NO. ASL NAM AD-250.11
PART II
87048

NAVAL AIR MATERIAL CENTER

NAVAL BASE

PHILADELPHIA, PA.

AERONAUTICAL STRUCTURES LABORATORY
REPORT ON

AIRSHIP STATIC HEAVINESS INDICATOR

ISSUED BY

NAVAL AIR EXPERIMENTAL STATION

NAVY—DPPO 4ND—PHILA., PA.

NAVAL AIR MATERIAL CENTER
Naval Air Experimental Station
Philadelphia 12, Pennsylvania

In reply refer to:
XT-31-DFP:bg
VZPK/F1
(925)

20 AUG 1954

From: Director, Naval Air Experimental Station
To: Chief, Bureau of Aeronautics (AD-221)

Subj: Report No. ASL NAM AD-250.11, Part II, "Airship Static Heaviness Indicator"

Ref: (a) BUAER ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952

Encl: (1) Sixteen copies of subject report

1. Enclosure (1) is forwarded for the Bureau of Aeronautics' information and files in completion of the work authorized by reference (a).

2. The equipment for obtaining a direct reading of airship static heaviness has been forwarded to the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, for evaluation and use in accordance with reference (a).

3. With the issuance of this report, the project is considered closed.

Wm. C. DUNN
By direction

BG

REPORT NO. ASL NAM AD-250.11
PART II

NAVY DEPARTMENT
BUREAU OF AERONAUTICS

REPORT ON

AIRSHIP STATIC HEAVINESS INDICATOR

BY

AERONAUTICAL STRUCTURES LABORATORY
NAVAL AIR EXPERIMENTAL STATION
NAVAL AIR MATERIAL CENTER PHILADELPHIA

Authorization . . . . . BUAER ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952

Dates of Development, Fabrication, and Test . . From 1 Nov 1953 To 20 May 1954

Reported by . . . . . D. H. Parry — Test Engineer
Electronic Scientist

Reviewed by . . . . . J. Jacobson — Section Supervisor
Supv Electronic Scientist

Approved by . . . . . D. E. Weiss — Division Head
Supv Electronic Scientist

Approved by . . . . . J. S. Kean — Head Engineer
Supv Aero Development Engr

Approved by . . . . . Wm. C. Dunn — Superintendent
Commander, USN — Aero Struc Lab

DATE ISSUED 10 Aug 1954

CONTENTS

REFERENCES

(a) NAS, Lakehurst, ltr F1 NA4-70-JCK:cp of 6 Sep 1951
(b) NAXSTA ltr XT-31-DHP:bg J15-5 (997) of 13 Oct 1953
(c) BUAER ltr Aer-AC-71 163479 of 22 Dec 1953

PLATES

ABSTRACT

A prototype airship static heaviness indicator has been developed. Resistance wire strain gages affixed to the trunnion of the type 9060A landing gear measure the vertical shear loads due to static heaviness. The strain gage bridge output is read directly in terms of pounds of static heaviness on a null-balancing type of indicator. The design and operating characteristics of the equipment are described. The equipment has been forwarded to the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, for evaluation and service use.

1. AUTHORIZATION

The development of an airship static heaviness indicator was authorized by BUAER ltr Aer-DE-221 ZPK 3101 of 8 Jan 1952. The design, fabrication, installation, and test of the equipment herein described were conducted from 1 November 1953 to 20 May 1954.

2. OBJECT

To develop a means of providing a direct visual reading of the static heaviness of an airship.

3. INTRODUCTION

The present method for obtaining the static heaviness of an airship is time-consuming and laborious. It is based on the removal or addition of weights manually to determine the equilibrium condition of the airship. The useful load of personnel, equipment, food, and fuel is then put on board and an estimate of the static heaviness is made which may be as much as ten percent inaccurate. A system for remote indication of the static heaviness of an airship which could instantaneously give more accurate readings in pounds would make possible considerable savings in time and man-power. A resistance wire strain gage bridge, permanently installed to measure vertical shear loads in the trunnion of the type 9060A landing gear manufactured by Cleveland Pneumatic Tool Company, is highly responsive to the static heaviness of the airship. Its output can be indicated at a remote location, providing a straightforward method of obtaining a direct reading of static heaviness.

4. DESCRIPTION

The system for providing a visual reading of static heaviness consists of a load-sensitive strain gage bridge on the trunnion of the type 9060A landing gear and a Baldwin Southwark type K SR-4 strain indicator modified to give direct readings of static heaviness from zero to 4,000 pounds. The strain gage bridge measures vertical shear load and consists of eight SR-4, type AD-7 resistance wire strain gages in a four-active-arm bridge. The completed and waterproofed installation of the gages on the trunnion is pictured in plate 1. The modified indicator contains balancing and calibrating units in addition to a self-contained, battery-operated power supply. The indicator employs a null-balancing circuit in which motion of a calibrated slide wire varies a bucking voltage to the output of the strain gage bridge. The difference between bridge and bucking voltages is amplified and indicated on an output meter which provides a very sensitive balance indication, independent of battery voltages and tube characteristics. Readings are taken when the output

4. DESCRIPTION (Continued)

meter indicates zero. Plate 2 is the front view of the static heaviness indicator. Plate 3 shows the modifications in the indicator circuit which provide for direct readings of static heaviness. A drawing of the Baldwin Southwark type K SR-4 strain indicator is reproduced in plate 5. A four-conductor shielded cable to connect the strain gage bridge to the indicator is drawn up from the landing gear into the car of the airship.

Before using the equipment, the condition of the batteries should be checked by setting the switch first on "A" and then on "B" and noting on the meter dial whether in each case the pointer is beyond the red range. If not, the batteries should be replaced by removing the cover from the bottom of the indicator case. Turn the power switch to "ON" and allow ten seconds for the warm-up of the tubes. At this point the zero setting should be checked. Turn the "STATIC HEAVINESS - POUNDS" indicator knob to read zero. With no load on the landing strut, i.e., the airship floating with the landing gear off the ground, note the reading on the upper meter. If it is not zero, loosen the "BALANCING" potentiometer lock-nut to permit the shaft to be turned by a screw driver. Rotate the shaft to give a zero reading on the meter and then lock the potentiometer in this position. The airship may now be loaded for take-off. As this is being done, the null-balancing pointer may be kept near zero by rotating the slide wire knob. When the airship is fully loaded, the null-balancing pointer is set exactly at zero by means of the knob. The static heaviness can then be read directly from the lower indicator.

The zero setting of the equipment should be checked prior to at least each of the first twenty take-offs. If no shift is perceptible, the zero determination need not be repeated as frequently. However, it should be checked after any unusually hard landing or other event which could disturb the bridge balance. Perhaps the most convenient time to do this is in flight when there is no vertical load on the landing gear.

The equipment should be re-calibrated about every two weeks. Using known weights or a scale under the landing gear, the indicator may be checked at a number of points up to 4,000 pounds heaviness. First check the zero setting, then load the airship and set the indicator to the applied weight. If the null-balancing meter pointer is not at zero, loosen the "CALIBRATING" potentiometer lock-nut and adjust until pointer is at zero. The shaft is then locked into position.

5. METHOD

a. Preliminary Calibrations

In the course of the development, it was found necessary to instrument two landing gears of the type 9760A. The first was instrumented while installed on the ZP2K-68 airship at the Naval Air Station, Lakehurst, New Jersey. A simple four-strain-gage, four-active-arm bending bridge was affixed to the trunnion. When unsatisfactory calibrations were obtained with this instrumentation, a more complex eight-gage, four-active-arm shear bridge was designed to reduce the large errors previously obtained. This strain gage bridge was installed on the second landing gear at the Naval Air Experimental Station. A loading jig and a loadometer, whose error was less than .5 percent of the full scale of 4,000-pounds static heaviness, were used to calibrate the landing gear. The weight indications were read on the modified SR-4 indicator. Calibrations of a four-gage bridge similar to the original bending bridge were obtained in addition to the calibration of the eight-gage bridge. The calibrations were compared.

b. Field Calibration

After the calibrations on the loading jig, the landing gear was installed on the ZP2K-68 airship for the field evaluation tests. The tests were conducted in the hangar. The loadometer which had been used in the laboratory calibrations was placed under the landing wheel of the airship to give indications of static heaviness. A calibration was run. On the succeeding day the zero shift was checked and another calibration was made.

6. RESULTS

a. Preliminary Calibrations

The unsatisfactory calibrations at the Naval Air Station, Lakehurst, New Jersey, using the simple four-gage bending bridge were due to a shifting of the point of load application on the landing strut trunnion. The errors were large and unpredictable, and tapping of the landing gear mounts produced significant changes in the reading. In the laboratory calibrations, where the shifting point of load application was roughly simulated, the results using the eight-gage shear bridge were greatly improved over those obtained with the four-gage bridge. The errors were reduced to within one percent of full scale of 4,000 pounds, and tapping caused almost no change in the readings.

b. Field Calibrations

The calibration curve is given in plate 4. Differences between static heaviness indication and loadometer readings did not exceed 100 pounds or 2.5 percent of full scale. There was no perceptible zero shift at the start of the second day's calibration.

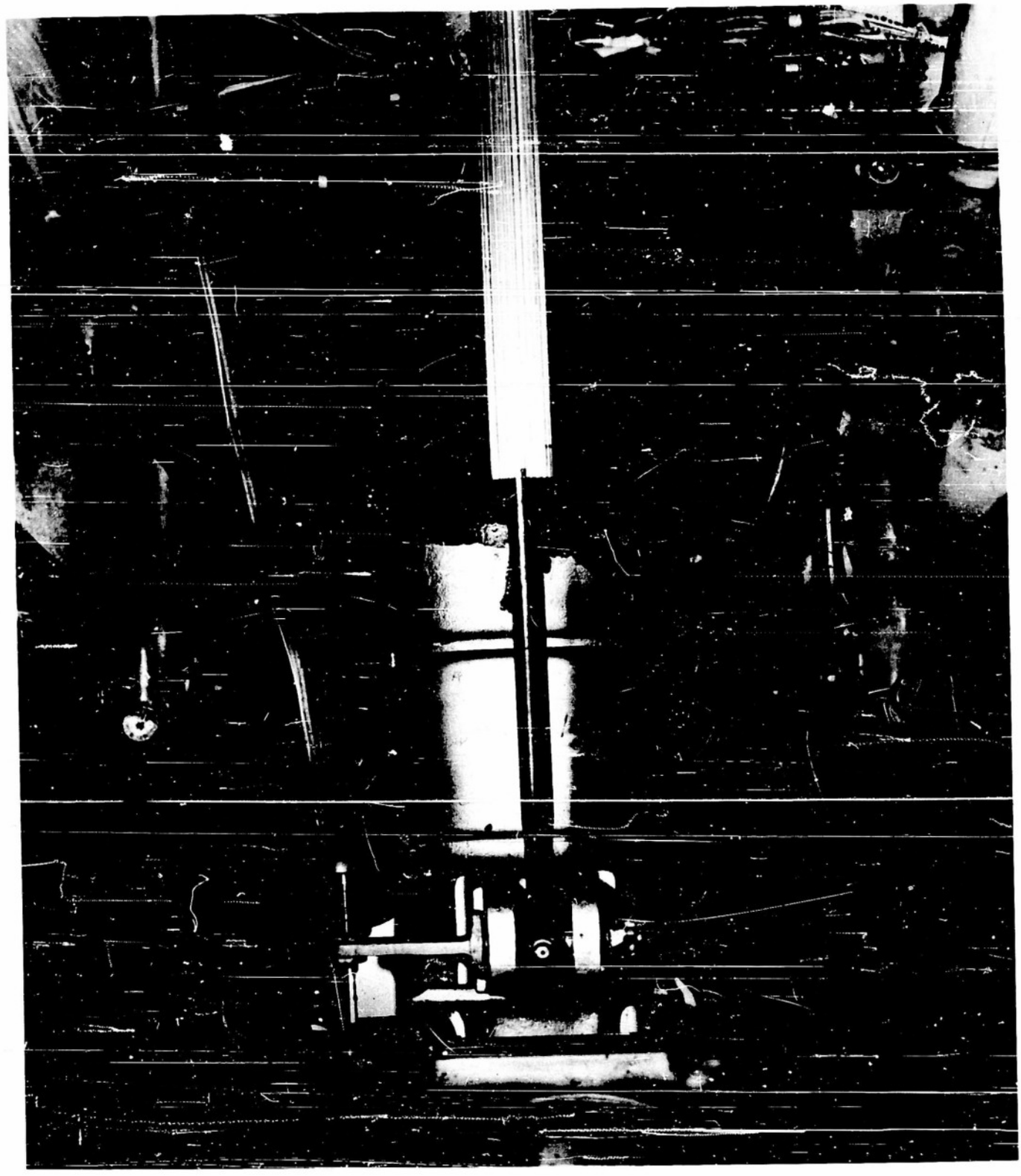
7. CONCLUSIONS

a. The static heaviness indicator provides a direct visual reading of the static heaviness of an airship.

b. It is estimated that errors should not exceed 2-1/2 percent of full scale under the still air conditions prevailing in a hangar.

8. RECOMMENDATIONS

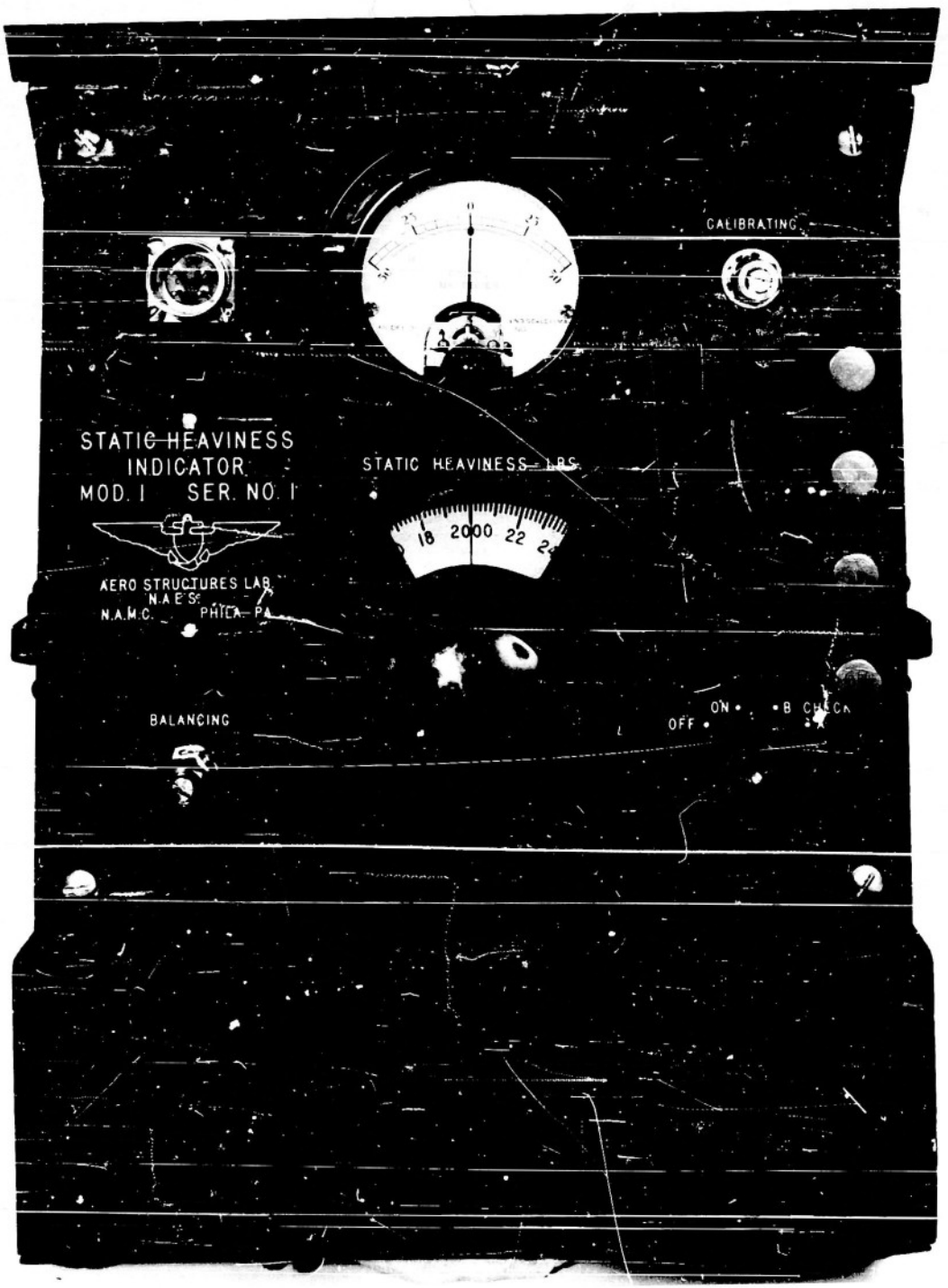
It is recommended that the equipment be evaluated for service use by the Chief of Naval Airship Training and Experimentation, Lakehurst, New Jersey, including tests under various wind conditions while the airship is masted outdoors.



COMPLETED STRAIN INSTALLATION ON TRUNNION OF LANDING GEAR

PHOTO: MAM6(1)-282918(L)-5-54

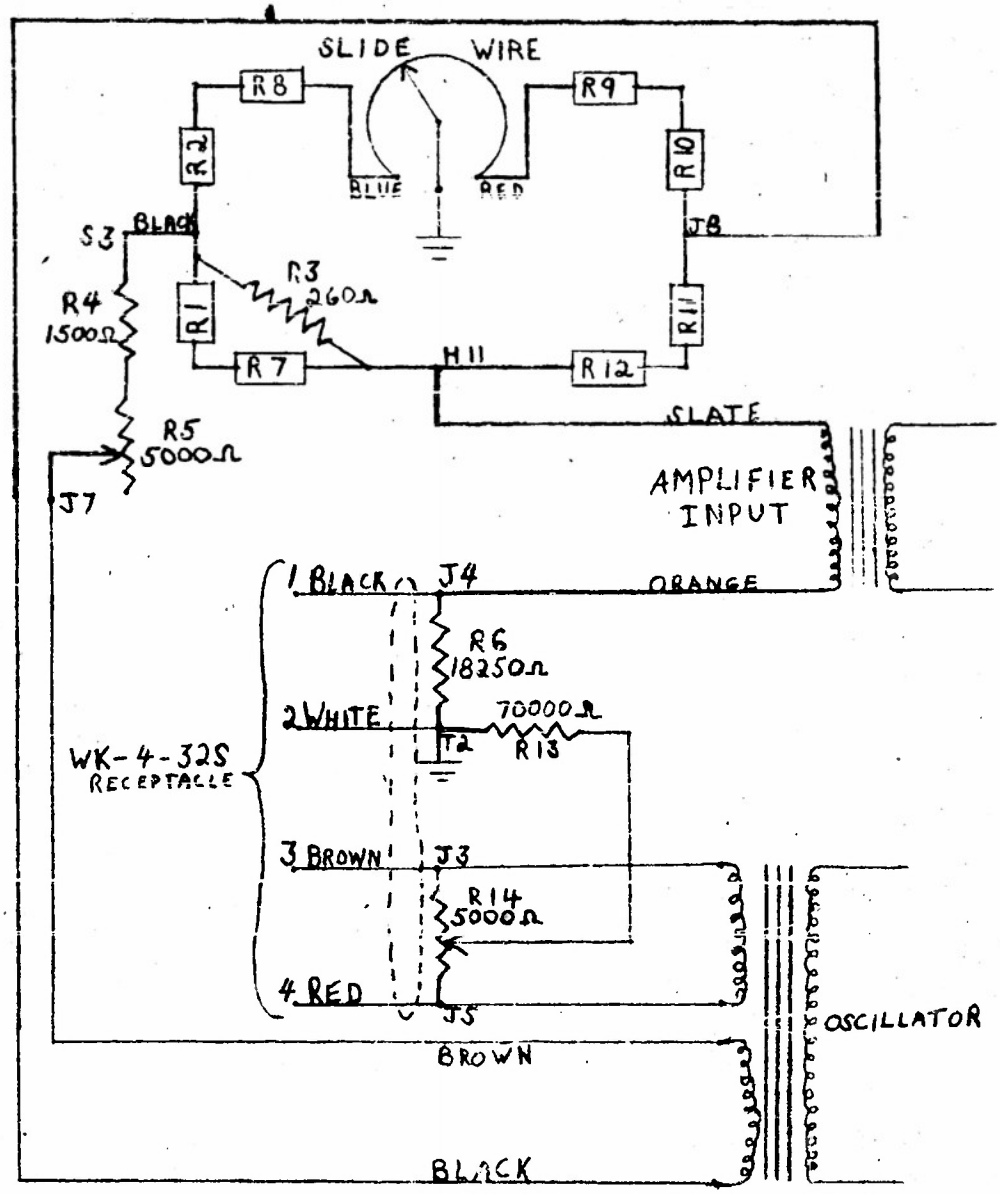
PLATE 1



STATIC HEAVINESS INDICATOR

PHOTO: NAM6(1)-282390(L)-5-54

PLATE 2



Unchanged		Modifications	
R1, R2, R10, R11 = 1.45Ω	R3 = 260Ω	R6 = 18,250Ω	
R7, R8, R9, R12 = 10Ω	R4 = 1,500Ω	R13 = 70,000Ω	
	R5 = 5000Ω calibrating pot.	R14 = 5,000Ω balancing pot.	

PORTION OF TYPE K SR-4 INDICATOR MODIFIED FOR CONVERSION TO STATIC HEAVINESS INDICATOR

PLATE 5

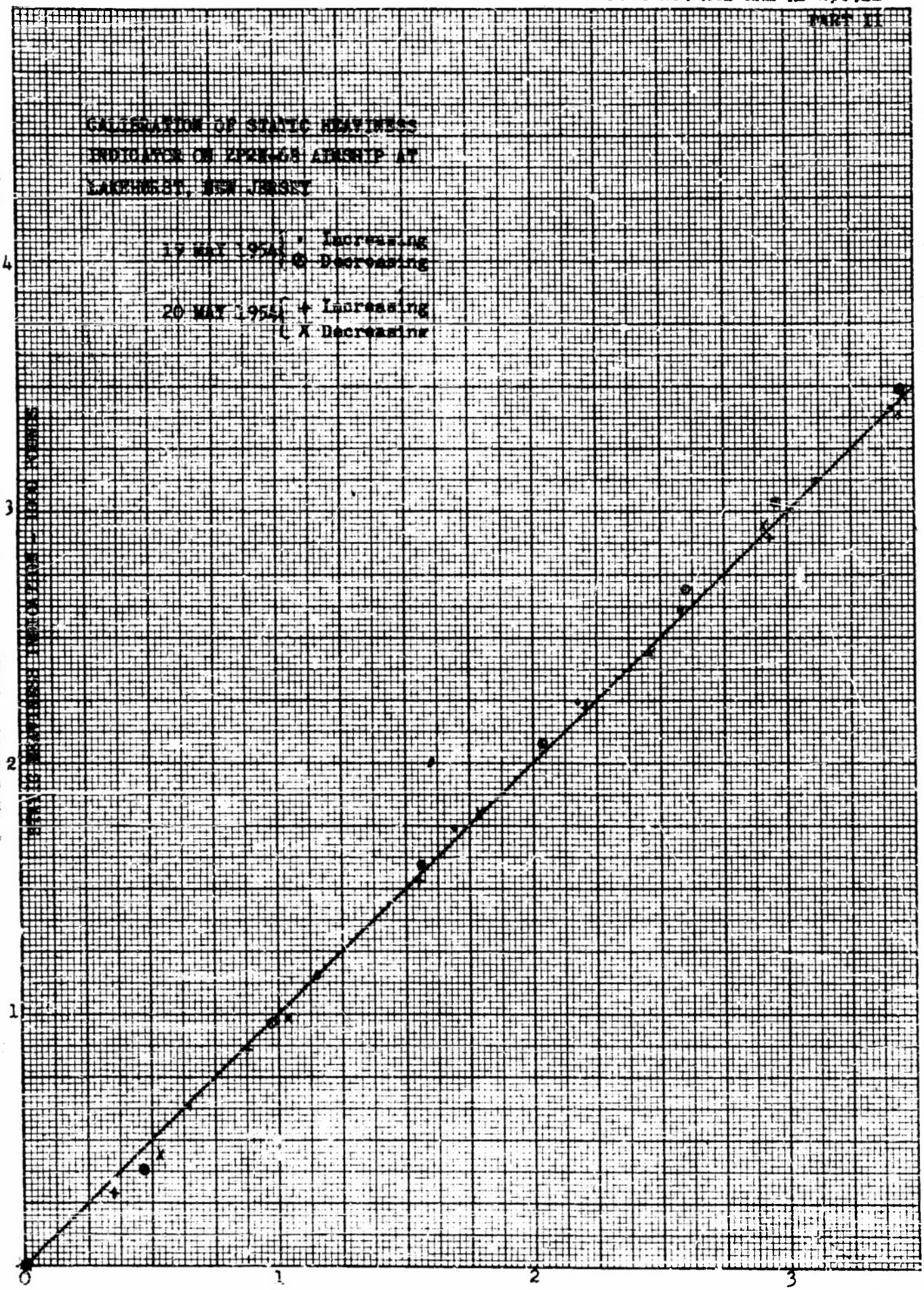
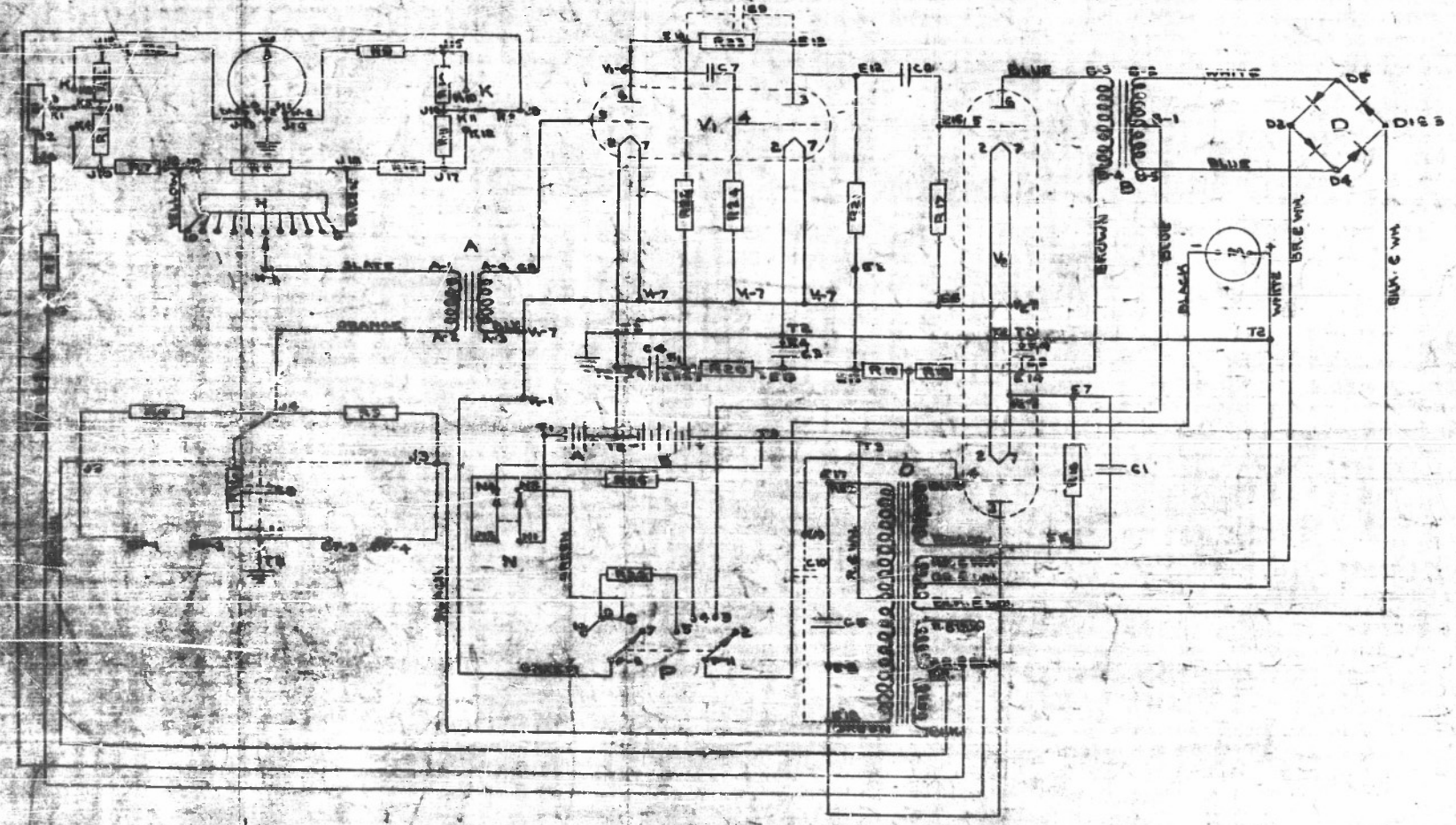

CALIBRATION OF STATIC HEAVINESS
INDICATOR ON ZPK-468 AIRSHIP AT
LAKEHURST, NEW JERSEY
17 MAY 1954 ⊙ Increasing
⊙ Decreasing
20 MAY 1954 + Increasing
X Decreasing
4
3
2
1
0
1
2
3
LOADOMETER READINGS - 1000 POUNDS

PLATE 4



LEGEND FOR PORTABLE STRAIN INDICATOR

A - INPUT TRANSFORMER	R1 - 1,450 OHMS
B - OUTPUT TRANSFORMER	R2 - 1,65 OHMS
C - OSCILLATOR TRANSFORMER	R3 - 120 OHMS
D - RECTIFIER	R4 - 120 OHMS
E - RESISTOR AND CONDENSER PANEL ASSN.	R5 - 251 OHMS
J - BRIDGE RESISTOR PANEL ASSN.	R6 - [illegible]
M - METER	R7 - 10. OHMS
N - PUSH BUTTON SWITCH	R8 - 10. OHMS
V - TUBES	R9 - 1.. OHMS
P - CHECK SWITCH	R10-1.95 OHMS
N - REFERENCE SWITCH	R11-1.95 OHMS
S - GAGE FACTOR RHEOSTAT	512-10 OHMS
BP - BINDING POST	R-13-1650 OHMS
K - RANGE EXTENDER SWITCH	R14-5000 OHMS
W - SLIDEWIRE TERMINAL BOARD	R17-1.0 MEG.
T - TERMINAL STRIP	R18-.1 MEG.
C1 - .25 MFD.	R19-.1 MEG.
C2 - .1 MFD.	R20-.1 MEG.
C3 - .1 MFD.	R21-.25 MEG.
C4 - .1 MFD.	R22-.25 MEG.
C5 - .03 MFD.	R23-2 MEG.
C6 - .002 MFD.	R24-.1 MEG.
C7 - .003 MFD.	R25-.1 MEG.
C8 - (PHASING)	R26-1000 OHMS
C9 - (PHASING)	
C10 - (PHASING)	

REV.	NO.	DATE	BY	PIECE NO.	REMARKS
3					
2					
1					

▽ ORDINARY MACHINE FINISH
▽▽ GOOD MACHINE FINISH
▽▽▽ REAM, GRIND OR POLISH
FRACTIONAL DIMENSIONS ARE ± 1/32"

DRAWN [illegible] ISSUED
TRACED [illegible]
EXAMINED [illegible] SCALE [illegible]
APPROVED [illegible]

BALDWIN SOUTHWARK DIVISION
THE BALDWIN LOCOMOTIVE WORKS
SOUTHWARK DEPT. PHILADELPHIA, PA.

TYPE K SR 4
STRAIN INDICATOR

DRAWING NO.